# Space Weather Technical Forecast

Issued on Sunday, 22 January 2023 at 13:30 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Chance of R1/R2 Radio Blackouts throughout. G1/Minor Geomagnetic Storms likely Day 2 (23rd) and a chance on Day 3 (24th).**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Low during the past 24 hours, with only C-class flares observed. The largest was a C8.4 flare observed at 22/1050 UTC from AR3192 in the northeast. There are currently eight sunspot regions on the visible disc, with a new, unnumbered sunspot recently emerged over the northeast limb. AR3190 in the southwest remains the largest and most complex region, which contains a single delta spot on the northern portion of its large leader spot. AR3192 in the northwest appears less complex than before, having lost the penumbra on its trailing portion of the group. AR3194 in the southeast is being monitored for the possible development of a delta spot in the rearward part of the group. All other sunspot regions are small, simple and appear to be relatively stable at this time. No Earth-directed CMEs have been observed in the past 24 hours.

**Solar Wind / Geomagnetic Activity:** Solar wind speeds, as measured at ACE, have been elevated to slightly elevated, with a peak 535km/s at 21/1239 UTC, before a gradual decline to near 430km/s by the end of the period. Density was predominantly at average levels. The IMF has been weak, with a peak of 8 nT at 21/1249 UTC. The north-south component (Bz) was also weak throughout with periodic fluctuations between positive and negative Bz (peak -7nT at 21/1305 UTC). The phi angle was largely positive (towards the sun), but with occasional transitions to the negative (away from sun) sector between 21/1200-22/0130 UTC. Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) as measured at GOES-16 has been at Background levels throughout. High energy electron flux (greater than 2 MeV) has been at background to moderate levels. The 24-hour integrated electron fluence stayed well below the Active threshold on a slowly increasing trend, with 2.94e6 integrated pfu observed at 22/0001 UTC.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is expected to be Low to Moderate, with a very slight chance of reaching High levels over the next four days. There are numerous candidate regions on the disc for significant flares, however, the most capable regions at this time are AR3190, 3192 and 3194.

**Solar Wind / Geomagnetic Activity:** The HSS from CH68 will gradually ease through Day 1 and 2 (22nd and 23rd) with solar winds reducing from slightly enhanced to background levels. Thereafter, a number of CMEs are forecast to potentially affect Earth between Days 2 and 3 (23rd and 24th), but with low-medium confidence in effects and timings. On Day 3, CH69 is expected to connect with Earth, with speeds of around 550 km/s likely. This continuing into Day 4 (25th). Generally Quiet geomagnetic activity is expected on Day 1 and early Day 2, with Active to G1/Minor storm likely on Days 2 and 3 due to potential CME arrivals and the HSS of CH69 respectively. These effects should start to start to wane Day 4, though with lower than average

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confidence.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux observed by GOES-16 is likely to remain at predominantly background levels, but with a slight chance of reaching S1 or greater through the period.

High energy electron flux remains at background to moderate levels. Electron flux should remain at background to moderate levels, although, with a chance of rising to high on Day 1 and 2 (22nd and 23rd). Possible CMEs on the 23rd and 24th may act to reduce the risk of Active electron fluence, as will the onset of the HSS from CH69, expected on Day 3 (24th). By Day 4 (25th) there is an increasing chance of high electron flux occurring. Electron fluence is expected to stay below the Active threshold through the period. Perhaps a rising trend towards the end of the period, as HSS and CME effects begin to wane.

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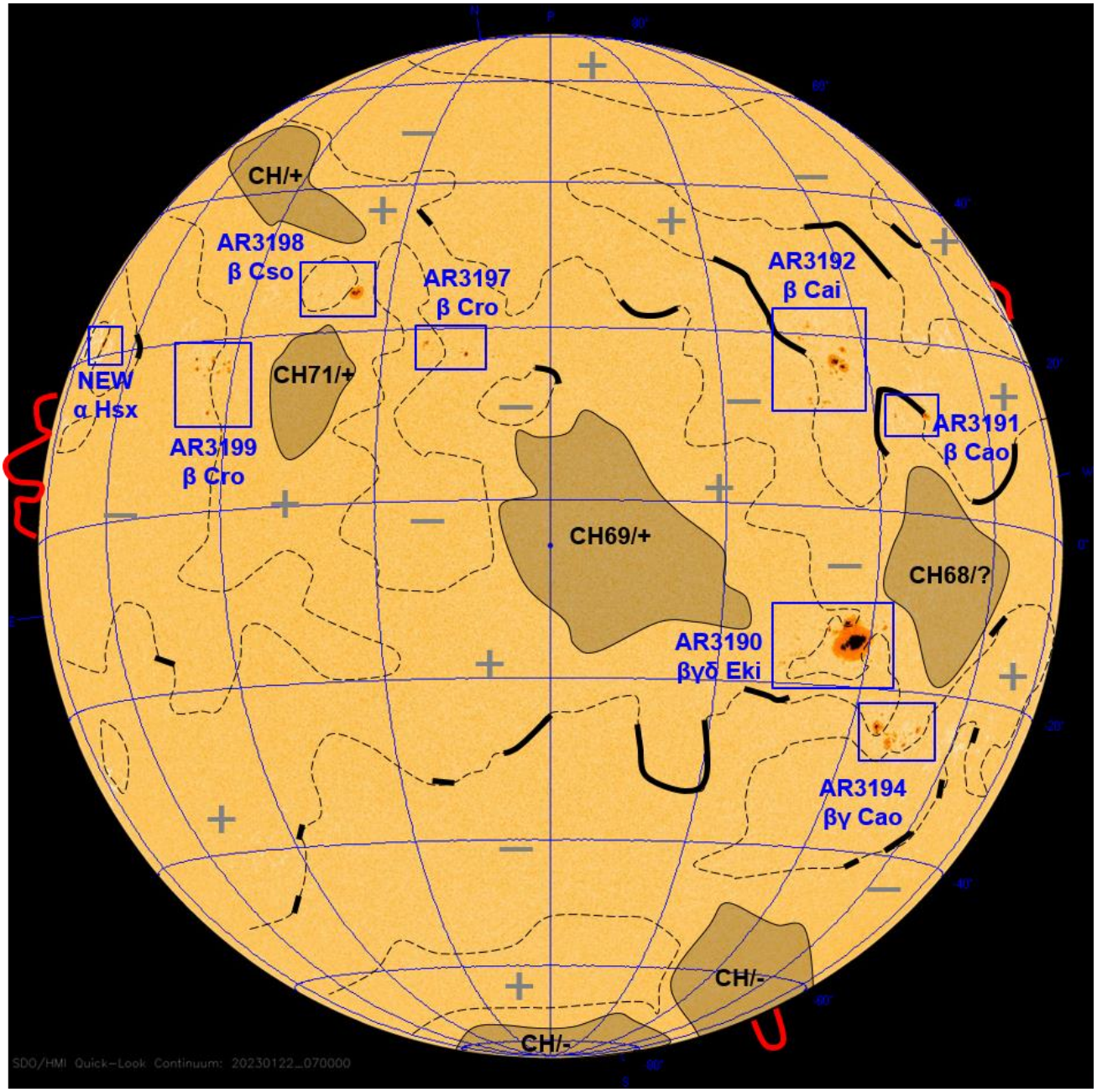
**Figure 1. Solar Analysis Valid 22/0700 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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# Met Office Space Weather Technical Forecast

## Geomagnetic Storms:

Earth is currently in a weak HSS from CH68, the effects of which will gradually wane through Day 1 (22nd) and the early part of Day 2 (23rd), bringing speeds from slightly elevated to background levels.

A number of CME's may effect Earth on the 23rd and 24th. The first from a faint halo signature associated with a flare from the NE on 19th. The second from a large, bright filament eruption from the SW on 20th. Shortly after this a flare originating from nearby AR3190 gave a mainly southward directed partial halo CME. All three could affect Earth, with somewhat uncertain geomagnetic effects as all are low-medium confidence to affect Earth.

Large CH69 located on the solar meridian is likely to connect with Earth on Day 3 (24th). This feature did not appear on previous rotation, therefore persistence is considered poor guidance. Speeds of around 550 km/s (elevated) could be expected with this feature.

A number of large filaments are evident on the sun's visible disc. If any of these were to lift-off in the coming days then they could manifest as geo-effective CMEs.

Generally Quiet geomagnetic activity is expected on Day 1 and early Day 2, with Active to G1/Minor storm likely on Days 2 and 3 (23rd and 24th) due to potential CME arrivals and the HSS of CH69 respectively. These effects should start to start to wane day 4 (25th), though with lower than average confidence.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 5 | 60 | 40 | 20 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 20/0940 | Full | Filament eruption | NE | 500 km/s | 23/0900 UTC | Very faint, low-medium confidence |
| 20/1847 | Partial | Filament eruption | SW | 770 km/s | 23/1200 UTC | Possible glancing blow, otherwise missing ahead of Earth. Medium confidence. |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 20/2222 | Partial | Flare | AR3190 | 450 km/s | 24/1800 | Possible glancing blow. Mainly missing below Earth. Low confidence. |

### Radio Blackouts - X-Ray Flares:

Solar activity has been Low during the past 24 hours, with only C-class flares observed. The largest was a C8.4 flare observed at 22/1050 UTC from AR3192 in the northeast.

Solar activity is expected to be Low to Moderate, with a very slight chance of reaching High levels throughout as the most complex regions continue to rotate west.

There are currently eight sunspot regions on the visible disc, with a new, unnumbered sunspot recently emerged over the northeast limb. AR3190 (Eki/Beta-Gamma-Delta) remains the largest and most complex region, which contains a single delta spot on the northern portion of its large leader spot. AR3192 no longer appears to have discernible penumbra on the trailer portion of the group, so is reclassified as a Cai/Beta-Gamma group, despite a slight increase in overall size. AR3194 is being monitored for the possible development of a delta spot in the rearward part of the group. Other sunspot regions are small, simple and appear to be relatively stable at this time.

| X Ray Flares<br>Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **R1-R2 M Class** | No | 60 | 60 | 60 | 60 |
| **Very Active** | **R3 to R5 X Class** | No | 5 | 5 | 5 | 5 |

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## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently at background levels.

While no recent S1+ events have been observed at GEO, the elevated number of front-sided groups dictates an elevated risk. AR3190 especially, contributes most of the risk as it continues to rotate westward into a more geo-effective sector. As such, a slight chance of S1 or greater continues through the four day period.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 15 | 15 | 15 | 15 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

High energy electron flux remains at background to moderate levels. Electron flux should remain at background to moderate levels, although, with a chance of rising to high during the diurnal peaks of Day 1 and 2 (22nd and 23rd). Possible CMEs on the 23rd and 24th may act to redistribute the electron fields, therefore reducing the risk of Active electron fluence, as will the onset of the HSS from CH69, expected on Day 3 (24th). By Day 4 (25th), as geomagnetic effects likely subside, there is an increasing chance of high electron flux occurring.

Electron fluence is expected to stay below the Active threshold through the period. Perhaps a rising trend towards the end of the period, as HSS and CME effects begin to wane. The MOSWOC REFM model is considered as a good overall trend for the four day period.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 5 | 10 | 5 | 20 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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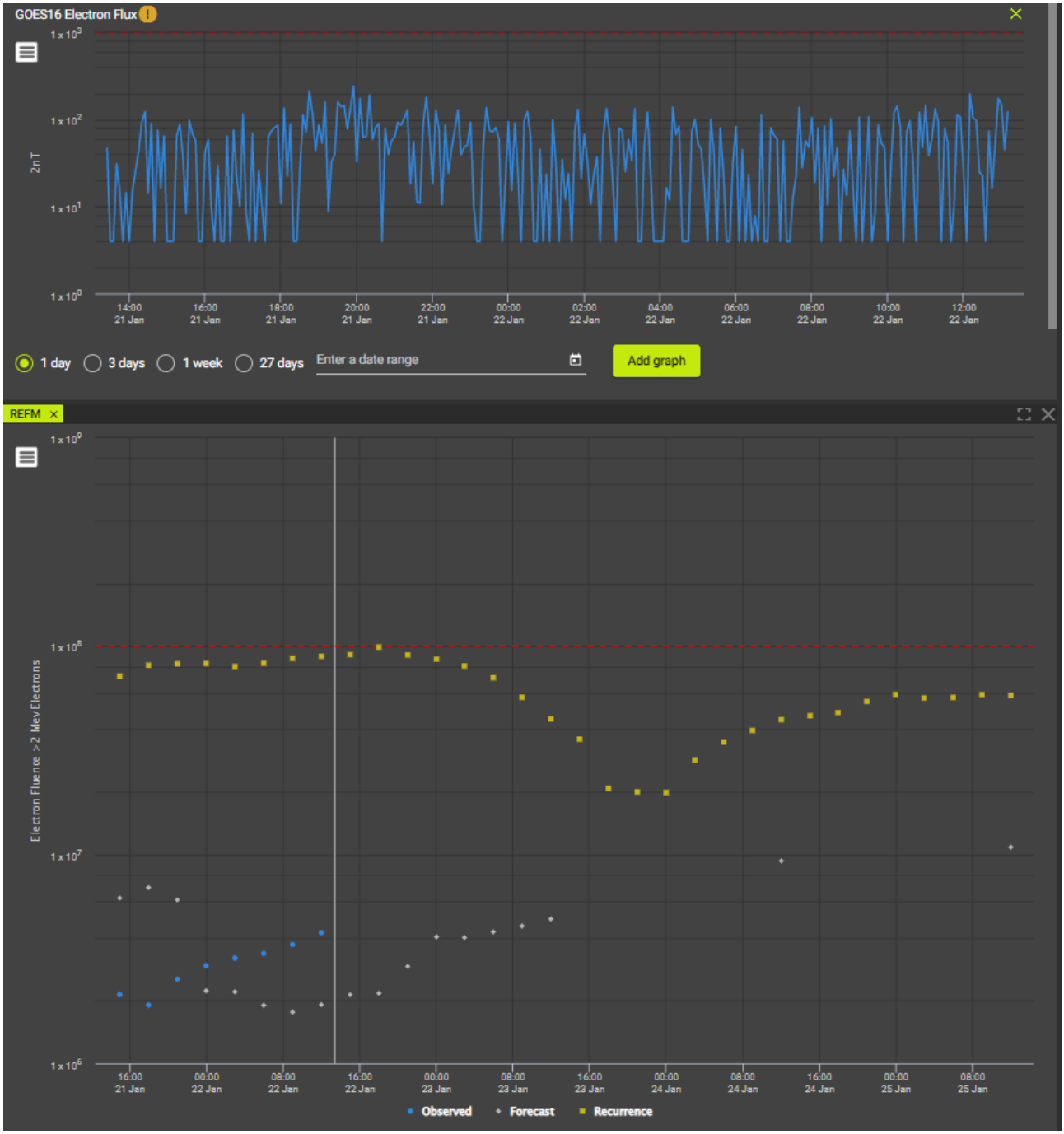
**Figure 3: Latest GOES16 Electron Flux (top) and MOSWOC REFM (below) output**

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